(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 132 060 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.09.2001 Bulletin 2001/37

(51) Int Cl.7: **A61F 2/06**

(21) Application number: **01610021.6**

(22) Date of filing: **07.03.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **09.03.2000 US 522292**

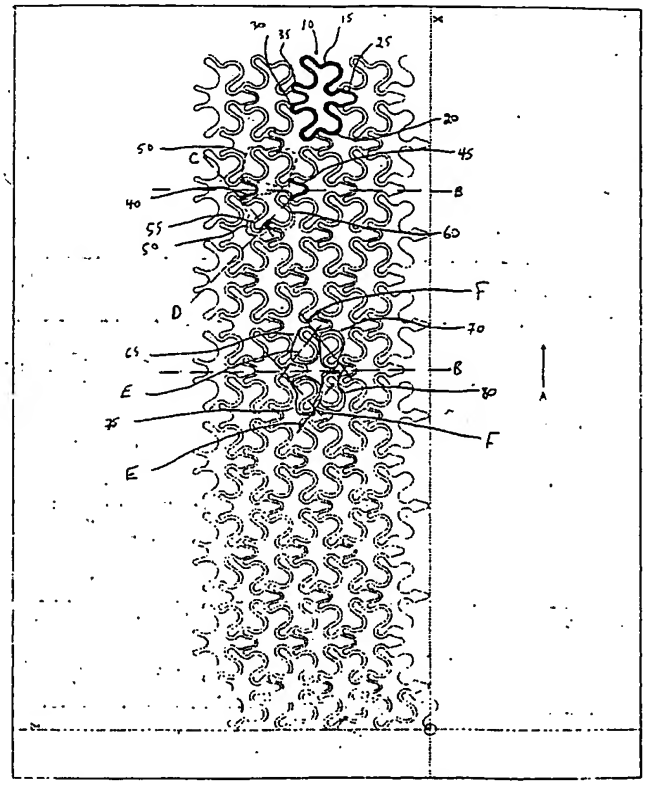
(71) Applicant: **LPL Systems Inc.**
Toronto, Ontario, M5L 1J3 (CA)

(72) Inventor: **Moore, Brian**
Mountain View, California 94043 (US)

(74) Representative:
Plougmann, Vingtoft & Partners A/S
Sankt Annae Plads 11,
P.O. Box 3007
1021 Copenhagen K (DK)

(54) Expandable stent

(57) There is described a novel stent design which has flexibility characteristics superior to currently available stent structures. Further, once the present stent is expanded, it exhibits an inherent tendency to maintain the shape of the lumen in which it is deployed. This is a significant advantage over many currently available stents which, upon expansion, tend to stretch and deform the lumen from its natural longitudinal orientation as the stent tends to straighten. The present stent is characterized by a porous surface having a repeating pattern generally in the shape of a "butterfly".



EP 1 132 060 A2

It would be further desirable if the improved stent could be manufactured readily. It would be further desirable if the improved stent could be deployed using conventional stent delivery systems.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide a novel expandable stent which obviates or mitigates at least one of the above-mentioned disadvantages of the prior art.

[0012] Accordingly, in one of its aspects, the present invention provides an unexpanded stent comprising a proximal end and a distal end in communication with one another, a tubular wall disposed between the proximal end and the distal end, the tubular wall having a longitudinal axis and a porous surface defined by a plurality of interconnected circumferential rows of a repeating pattern, the repeating pattern comprising a concave-shaped wall and a convex-shaped wall aligned substantially along an axis substantially orthogonal to the longitudinal axis.

[0013] In another of its aspects, the present invention provides an unexpanded stent comprising a proximal end and a distal end in communication with one another, a tubular wall disposed between the proximal end and the distal end, the tubular wall having a longitudinal axis and a porous surface defined by a plurality of interconnected circumferential rows of a repeating pattern, the repeating pattern comprising a concave-shaped wall and a convex-shaped wall aligned in manner such that individual repeating patterns in the a circumferential row are interlocked with respect to one another.

[0014] In another of its aspects, the present invention provides an unexpanded stent comprising a proximal end and a distal end in communication with one another, a tubular wall disposed between the proximal end and the distal end, the tubular wall having a longitudinal axis and a porous surface defined by a plurality of interconnected circumferential rows of a repeating pattern, the repeating pattern comprising four S-shaped sections orientated such that, for at least two pairs of the S-sections, one S-shaped section is a mirror image of the other S-shaped section along an axis orthogonal to the longitudinal axis.

[0015] In yet another of its aspects, the present invention provides an expandable stent comprising a proximal end and a distal end in communication with one another, a tubular wall disposed between the proximal end and the distal end, the tubular wall having a longitudinal axis and a porous surface defined by a plurality of interconnected circumferential rows of a repeating pattern, the repeating pattern being substantially free of straight sections and having a multi-lobed shaped perimeter and being oriented in place by at least six 3-point junctions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Embodiments of the present invention will be described with reference to the accompanying drawing which illustrates a two-dimensional view of a preferred design of the present stent.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Thus, the present inventors have developed a novel stent design which has flexibility characteristics superior to currently available stent structures. Further, once the present stent is expanded, it exhibits an inherent tendency to maintain the longitudinal shape of the lumen in which it is deployed. This is a significant advantage of the present stent compared to many currently available stents. Specifically, upon expansion, many currently available stents tend to stretch and deform the lumen along its length from its natural orientation as the stent tends to straighten.

[0018] The present stent is characterized by a repeating pattern containing a strut architecture in which a given strut in the repeating pattern serves the dual role of flexibility and expansion/radial rigidity in the two states of the stent. Thus, the present stent is particularly robust in situations of complex deformation states that may be encountered *in vivo*. This includes (but is not limited to) simultaneous bending, calcific lesions, torsion and expansion. The present stent also has desirable uniformity of expansion under extreme conditions.

[0019] The present stent deforms with minimal or no distortion and with minimal or no significant deformations in localized areas. The deformation is smooth and thus the cylindrical profile is smooth.

[0020] Upon expansion, the repeating pattern in the present stent becomes expanded, ideally to a truss-like shape, which results in very desirable radial rigidity. Further, the present stent has a desirable strut density when expanded thereby resulting in excellent vessel coverage while allowing side branch access.

[0021] Other advantages of the present stent design will be readily apparent to those of skill in the art.

[0022] The present stent may be constructed from any suitable starting material. Preferably, the starting material is a thin tube of a metal or alloy. Alternatively, it is possible to construct the present stent from a flat sheet which preferably is cut (as described below), rolled and then welded.

[0023] In one preferred embodiment, the starting material may be one which is plastically deformable - non-limiting examples of such a material include stainless steel, titanium, tantalum and the like. In another preferred embodiment, the starting material may be one which expands via temperature-dependent memory (i. e., a material which will expand upon reaching a certain temperature) - non-limiting examples of such a material include nitinol and the like.

[0038] As shown, it is preferred that the four S-shaped sections have substantially the same shape.

[0039] . Further pair of S-shaped section 65,80 each comprise an axis E passing through an initial point and an end point of the S-shaped section to define a pair of axes E in substantially parallel alignment. Still further, pair of S-shaped sections 70,75, each comprise axis F passing through an initial point and an end point of the S-shaped section to define a pair of axes F in substantially parallel alignment. As shown axes E and F are angled with respect to longitudinal axis A. Further, axes E and F are acutely angled with respect to one another.

[0040] The present stent may be used in a conventional manner. For example, the present stent may be mounted on a balloon expandable catheter and employed conventionally in a catheterization technique - see, for example, any of the references described above.

[0041] While the present invention has been described with reference to preferred and specifically illustrated embodiments, it will of course be understood by those skilled in the art that various modifications to these preferred embodiments and illustrated embodiments may be made without departing from the spirit and scope of the invention. For example, while the foregoing description has been in relation to the manufacture and use of a monotubular stent, those of skill in the art will immediately recognize that it is possible to employ the present stent in the form of a bifurcated stent. When the present stent is constructed as a bifurcated stent, it may be implanted using the procedure outlined in the '997 patent application referred to above. Such a bifurcated stent may be manufactured, inter alia, by any of the methods disclosed in the Canadian patent application number 2,175,720 filed on May 3, 1996. Other modifications which do not depart from the spirit and scope of the present invention will be apparent to those of skill in the art.

[0042] All publications, patents and patent applications referred to herein are incorporated by reference in their entirety to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated by reference in its entirety.

Claims

1. An unexpanded stent comprising a proximal end and a distal end in communication with one another, a tubular wall disposed between the proximal end and the distal end, the tubular wall having a longitudinal axis and a porous surface defined by a plurality of interconnected circumferential rows of a repeating pattern, the repeating pattern comprising a concave-shaped wall and a convex-shaped wall aligned in manner such that individual repeating patterns in the a circumferential row are interlocked with respect to one another.

2. The stent defined in claim 5, wherein the concave-shaped wall and the convex-shaped wall are interconnected by a pair of S-shaped walls.

3. The stent defined in claim 5, wherein each S-shaped wall comprises at least one S-shaped section having an axis passing through an initial point and an end point of the S-shaped section.

4. The stent defined in claim 7, wherein S-shaped section comprises an asymmetric pair of curved sections.

5. The stent defined in claim 8, wherein each curved section comprises an arc of at least about 180°.

6. The stent defined in claim 6, wherein each S-shaped wall comprises: a first S-shaped section having a first axis passing through an initial point and an end point of the first S-shaped section and a second S-shaped section having a second axis passing through an initial point and an end point of the second S-shaped section.

7. The stent defined in claim 10, wherein each of the first axis and the second axis are angled with respect to the longitudinal axis.

8. The stent defined in claim 10, wherein the first axis and the second axis are acutely angled with respect to one another.

9. The stent defined in claim 5, wherein the repeating pattern is substantially free of straight sections.

10. The stent defined in claim 5, wherein the tubular wall has a substantially circular cross-section.

11. The stent defined in claim 5, wherein the tubular wall is constructed of a plastically deformable material.

12. An unexpanded stent comprising a proximal end and a distal end in communication with one another, a tubular wall disposed between the proximal end and the distal end, the tubular wall having a longitudinal axis and a porous surface defined by a plurality of interconnected circumferential rows of a repeating pattern, the repeating pattern comprising four S-shaped sections orientated such that, for at least two pairs of the S-shaped sections, one S-shaped section is a mirror image of the other S-shaped section along an axis orthogonal to the longitudinal axis.

13. The stent defined in claim 16, wherein each of the